A Review on Role of wide hybridization in crop improvement

Comment [MF1]: the role

Abstract

Wide hybridization in crop plants involves crossing two distantly related species to initiate desirable traits, such as disease resistance, into a cultivated crop. This technique expands the genetic diversity accessible for breeding programs, enhancing the adaptability and resilience of crops. Wide hybrids often surpasslimitations of conventional breeding by incorporating unique genetic material. However, difficulties arise due to reproductive barriers and genomic incompatibilities between divergent species. Researchers employ techniques like embryo rescue and tissue culture to overcome these hurdles. Despite its potentiality, wide hybridization requires careful selection and extensive backcrossing to stabilize desired traits. The resulting crops may show improved resistance to pests, diseases, or environmental stressors, contributing to sustainable agriculture and food security. Continuous advancements in molecular biology and genomics facilitate the identification and transfer of specific genes, accelerating the development of wide hybrid varieties with enhanced agronomic traits.

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Key words: Wide hybridization, resistant, pest, disease and agronomic traits

Introduction

Hybridization has played a major role in the evolution of lineages. Hybridization between individuals from different species, belonging to the same genus or to different genera is termed as distant hybridisation or wide hybridization. When individuals from two distinct species of the same genus are crossed, it is known as inter-specific hybridization. When individuals being crossed belong to species from two different genera, it is referred as inter-generic hybridization. Wide hybridization comprises the exchange or modification of the genes due to crossing between species from distant gene pools. It is a unique tool to introduce useful traits in a variety of agricultural applications especially beneficial agronomical traits. It plays a substantial role in transferring traits of interest like disease and insect resistance, improved quality, early growth, dwarfism, increased yield, abiotic stress tolerance in crop plants besides bringing changes in the mode of reproduction as well. Wide hybridization involving crop wild relatives and related taxa has gained momentum in the recent fruit crop improvement programs (**AnushmaPL*et al*.,2020)**. Wide hybridization serves

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as a important tool in agricultural applications, facilitating the introduction of valuable traits that improve crop performance. Its importance extends beyond mere trait acquisition, as it also induces modifications in the reproductive mechanisms of the resulting hybrids. In the realm of crop improvement, wide hybridization stands out as a unique strategy, contributing to the sustainable enhancement of agronomic traits. By harnessing the genetic potential residing in distant gene pools, wide hybridization offers a pathway towards creating resilient and high-yielding crop varieties, thus addressing the evolving challenges in agriculture. Wide hybridization improves crop improvement programs by exchanging and modifying genes through crossbreeding different species. This dynamic process improves the momentum of recent agricultural advancements, enabling the introduction of beneficial traits that contribute to increased crop resilience, productivity, and adaptability in response to evolving environmental and economic challenges (**Patnaik *et al*.,2021).**

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Role of Wide Hybridization

The green revolution in India has transformed the country from a food grain deficit to a surplus nation, but it has also resulted in reduced varietal diversity and increased uniformity in appearance and harvestable products. This has made agriculture more susceptible to natural calamities and the emergence of new pathogen races, leading to disease outbreaks and significant yield losses. The major role of wide hybridization in crop improvement are:

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- Yield enhancement
- Improvement in quality
- Pest and disease resistance
- Abiotic and biotic stress resistance
- Development of new crop species

Desired characters like resistance against pest and diseases, morphological characters and their responsible genes are mostly used in wild species, genera and species connected to the cultivars. It is used in primary and secondary gene by inter-specific and inter-generic hybridization (**Patnaik*et al*., 2021)**.

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Wide hybridisation in amaranthus

Comment [MF16]: hybridization

The side effects of the green revolution include the emergence of new pathogen races and abiotic stresses, resulting in significant yield loss. Wide hybridization in amaranthusis suggested as a solution to address these challenges and improve agricultural productivity. Wide hybridization can introduce genetic diversity and enhance the resilience of crops to abiotic stresses, such as drought, flood, salinity, and high temperature. The utilization of wide hybridization techniques can lead to the progress of amaranthus with improved yield and quality, contributing to the goal of feeding the growing population **(Pooja P. Gowda*et al.*, 2020).**Wide hybridization plays a crucial role in improving the adaptability of vegetable crops by introducing genetic diversity and enhancing their ability to withstand abiotic stresses and biotic pressures.

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In a study involving 100 accessions of grain amaranth, comprising 50 from India and 50 from exotic sources, grown in a complete randomized block design, diverse characteristics were observed, with genotypes grouped into 10 clusters. Clusters I, VII, VIII, IX, and X displayed significant genetic distance from others. Correlation and path analysis underscored the importance of inflorescence length, number of leaves, and plant height in selecting high-yielding genotypes, irrespective of their geographic origin (**Rana *et al.*,*2005*)**.

Pseudo-xenic Effect of Allied *Annona* spp. Pollen in Hand Pollination of cv. 'ArkaSahan' [(*A. cherimola* × *A. squamosa*) × *A. squamosa*]

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In the study investigating the efficacy of hand pollination in alleviating fruit set issues in Annonaceous fruits, it was observed that Annona species such as A. *squamosa*could significantly enhance fruit set and quality traits in cv. ArkaSahan. A total of 1080 flowers in 2003 and 3420 in 2004 were subjected to pollination with various Annona species pollen, alongside self-pollination. Results indicated significant effects of pollen source on various fruit traits, including fruit set, weight, size, and maturation period, with A. *squamosa* pollen demonstrating the highest fruit set and heaviest fruits. Moreover, fruits resulting from A. *squamosa* pollen exhibited quicker maturation and minimal weight loss upon ripening. Evaluation of fruit pulp quality revealed significant variations influenced by pollen source, particularly in total soluble solids and acidity. Additionally, seed count per 100g fruit varied with pollen source, with A. *reticulata* pollen yielding higher seed counts and better fruit size and symmetry. The study underscores the potential for exploiting pseudo-xenia effects in fruit culture, emphasizing the practical significance of utilizing A. squamosa pollen for successful hand pollination in cv. ArkaSahan. (**S.H. Jalikop, 2007)**

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First Fruiting Intergeneric Hybrids between *Citrus* and *Citropsis*

The first reported fruiting hybrids between Citrus L. and Citropsis have been achieved through conventional hybridization, utilizing Citrus wakonai and Citropsis. Despite the seeds being half the normal size, an impressive 90% germinated without embryo rescue techniques. After initial losses, 327 surviving hybrids were potted on after six months, showing vigorous growth on their own roots. Within two years, 35 hybrids flowered continuously, albeit pollen-sterile, with ovaries abscising shortly after petal fall. Nonetheless, at 25 months, two newly flowering hybrids exhibited fruit set, marking a significant milestone in the development of this unique germplasm with implications for future breeding endeavors. (**Malcolm W. Smith *et al.,*** *2013)*

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Interspecific hybridisation for improvement of Brassica crop

Comment [MF23]: hybridization

In the Brassica genus, there are several crop species that allocateclose relationships, such as rapeseed (*Brassica napus*), which is an ancestral hybrid between turnip (B. rapa) and cabbage (*B. oleracea*). Mustard species like *B. juncea*, *B. carinata*, and *B. nigra* also share genomes with the Brassica crop species. The Brassica genus offers potential for crop advancement through inter-specific hybridization due to the close relationships between crop species and their wild relatives. Embryo rescue techniques have been effectively used to relocate useful traits between Brassica species, such as triazine resistance from B. napus to B. oleracea. Natural hybridization between distant relatives in the Brassica genus is rare, emphasizing the importance of conducting controlled hybridizations **(Elvis Katche*et al.*, 2019).**

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Utilization of wild relatives of Sorghum in wide hybridisation

Comment [MF26]: hybridization

Sorghum, with its diverse species, provides significant genetic and genomic variation, making it a suitable candidate for wide hybridization. Traits such as resistance to sorghum midge, shoot fly, and spotted stem borer have been documented in many sorghum species, including those outside the section Eusorghum . The Inhibition of Alien Pollen gene has been used to produce inter-specific hybrids with species from sections Chaetosorghum, Parasorghum, and Stiposorghum, overcoming pre-fertilization barriers. Post-fertilization barriers can be eliminated through embryo rescue techniques and the use of 2n gametes, allowing for gene transfer between species **(George L. Hodnett*et al*.,2020)**.

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Wide hybridization in food legumes

Inter-specific hybridization has been used to relocate foliar and viral disease resistance genes into inter-specific derivatives of groundnut. Inter-specific derivatives of pigeon pea obtained through crossing *Cajanusplatycarpus* with *C. cajan* have resistance to Phytophthora blight disease, a trait inherited from the wild species **(NaliniMallikarjuna,2003).**

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Conclusion

In conclusion, wide hybridization holds significant promise as the next horizon for crop improvement. This approach, which involves crossing distantly related species, has the capacity to unlock valuable genetic diversity and introduce novel traits that can improve crop resilience, yield, and nutritional content. As global challenges such as climate change and population growth intensify, the ability to utilize the genetic potential offered by wide hybridization becomes increasingly essential. While there are obstacles and intricacies associated with this technique, ongoing research and technological advancements are laying the way for its successful implementation. Adopting wide hybridization as a tool for crop improvement highlights a proactive and forward-thinking strategy in ensuring food security and sustainability in the face of evolving agricultural landscapes.

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